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(54) EXPOSURE METHOD AND MASK

(57)Abstract:

PURPOSE: To prevent the drop of the accuracy in alignment by suppressing the occurrence of dishing by flattening, in a photolithography process for manufacturing a semiconductor element, etc.

CONSTITUTION: The distortion of the observed image of a wafer mask is prevented by forming a wafer mark 76X, which has fine sub patterns 74A-74E between the fellow projections 71A-75D arranged at specified intervals, on a wafer W thereby suppressing the occurrence of dishing phenomena on the surface of the flattening film 79 on a wafer mark 76X. Moreover, a reticle for forming the wafer mark 76X has a reticle mark where fine light and dark patterns are arranged between transmission parts or dark parts with specified widths.

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CLAIMS

[Claim(s)]

[Claim 1] The 2nd process which forms a coat on the mark for said alignment of the 1st process which forms on a substrate the mark for alignment which consists of a concavo-convex pattern, and the; aforementioned substrate, and other fields; according

to the 3rd process, and the; this 3rd process which carry out flattening of said coat In the exposure approach of having the 4th process which applies sensitive material on said coat by which flattening was carried out, and exposes a mask pattern, and;, the mark for said alignment formed at said 1st process The exposure approach characterized by forming the concavo-convex pattern of a pitch smaller than said predetermined width of face between the heights more than predetermined width of face.
[Claim 2] Spacing of the heights more than said predetermined width of face of the mark for [said] alignment is the exposure approach according to claim 1 characterized by being 2 micrometers or more.
[Claim 3] It is the mask with which it sets on the mask with which the original edition pattern of the mark for alignment was formed with the pattern for an imprint, and the original edition pattern of the mark for [said] alignment is characterized by forming the light-and-darkness pattern of a pitch smaller than said predetermined width of face between two or more bright sections or dark space more than predetermined width of face.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the mask used by the exposure approach of having a planarizing process especially in the photolithography of

semi-conductor manufacture, and the exposure approach of having a planarizing process about the mask used by the exposure approach and this exposure approach.

[0002]

[Description of the Prior Art] In case a semiconductor device or a liquid crystal display component is manufactured at a photolithography process, the aligner which exposes the patterns (or photo mask etc.) of reticle to each shot field on the wafers (or glass plate etc.) with which it was applied to sensitization material is used. As this kind of an aligner, stepping (stepping) of the wafer stage in which the wafer was laid is carried out, and the so-called aligners (stepper etc.) of the step-and-repeat method which repeats the actuation which carries out sequential exposure of the pattern of reticle to each shot field on a wafer are used abundantly. Moreover, the projection aligner of so-called step - which exposes the pattern of reticle to a field larger than the exposure field of a projection optical system, and - scanning method is also developed by scanning reticle and a wafer synchronously recently.

[0003] In a place, since many semiconductor devices are formed in piles in the circuit pattern of a layer (a large number Rhea) on a wafer, in case the circuit pattern after a two-layer eye is exposed on a wafer, for example, it is necessary to perform alignment with the pattern image of the each shot field in which the circuit pattern was already formed and reticle on a wafer, i.e., the alignment of a wafer and reticle, (alignment) to accuracy. For this reason, the wafer mark for alignment is prepared with a circuit pattern on a wafer, and, generally the method of using that wafer mark for the alignment of the circuit pattern of a next layer is adopted.

[0004] As an alignment sensor used for measurement of the location of this wafer mark The LSA (Laser Step Alignment) method which detects the location of a mark by the light which irradiated laser light at the wafer mark on a wafer, and was diffracted and scattered about, The FIA (Field Image Alignment) method which carries out the image processing of the wafer mark which illuminated the halogen lamp with light with the wide wavelength bandwidth made into the light source, and measures it, Or the laser light which changed the frequency into the wafer mark of the shape of a diffraction grating on a wafer slightly is irradiated from a 2-way. The two generated diffracted lights are made to interfere and there are things, such as a LIA (Laser Interferometric Alignment) method which measures the location of a wafer mark from the phase of the interference light. Among these, a LIA method is the most effective for detecting the location of the wafer mark on the wafer whose wafer and front face of a low level difference were ruined, and corresponds to the flattening technique mentioned later.

[0005] By the way, the configuration of the wafer mark for [this] alignment, a number,

or magnitude is selected according to the condition of the layer on the resolution of the projection optical system of an aligner, a required alignment precision, and a wafer etc. As the configuration, although various configurations, such as a thing of the shape of the shape of a slit, the shape of a dot, and a grid, are generally used, it is formed only by the concavo-convex pattern by which these wafer marks' have comparatively big crevices (4-micrometer width of face, 6-micrometer width of face, etc.), and their were periodically arranged between heights in most cases conventionally.

[0006] Now, the multilayer interconnection is necessary flow today by high integration, densification, etc. which are looked at by the VLSI etc. The flattening technique which carries out flattening of the front face of the film of a predetermined layer among required process techniques on implementation of this multilayer-interconnection structure is dramatically important. This flattening is becoming a technique unavoidable also in the process which makes the integrated circuit of multilayer structure in order to realize a multilayer interconnection. Although this flattening is usually performed by the chemical approaches, such as anodic oxidation method, the resin applying method, a glass Floe process, the etchback method, the lift-off method, and a bias sputtering technique, processing (chemical machinery-polish processing) of grinding the front face of the film generated on the substrate by the above-mentioned approach in chemical machinery if needed in addition to this approach is also performed.

[0007]

[Problem(s) to be Solved by the Invention] However, if a crevice 2 micrometers or more exists in the substrate pattern of the metal membrane which is under the film by which flattening is carried out in the case of flattening processing by this chemical machinery-polish, the phenomenon which a dished hollow generates on the film front face of that part and which is called the so-called dishing (dishing) will arise. Therefore, it has comparatively big crevices (4-micrometer width of face, 6-micrometer width of face, etc.) like the conventional wafer mark, and when formed only by the concavo-convex pattern by which they were arranged periodically, the same phenomenon arises in the front face of the film formed on it. The situation is shown in drawing 8 .

[0008] Drawing 8 (a) shows the condition of having formed the oxide film 92 on the substrates 93, such as a wafer, having formed crevice 90a upwards by etching, and having formed the metal coat 91 by the spatter of aluminum etc. Then, the condition after performing the above-mentioned chemical machinery-polish processing is shown in drawing 8 (b). In drawing 8 (b), when the width of face of crevice 90a is 2 micrometers or more, dishing D1 occurs on crevice 90a. Moreover, when the pattern

with which two or more crevice 90b was arranged periodically is formed on a substrate 93 as shown in drawing 9 (a), and the metal coat 91 is put on this pattern, dishing happens similarly, but if chemical machinery-polish processing is performed in this case, as shown in drawing 9 (b), the big dishing D2 will occur on the list of crevice 90b. Therefore, as shown in drawing 9 (c), when heights 90c uses the wafer mark M which consists of line - and - tooth-space pattern which were arranged periodically, the big dishing D3 occurs on the wafer mark M. For this reason, when detecting by the alignment system, distortion took place to the observation image of a wafer mark, and there was inconvenience that alignment precision got worse.

[0009] In view of this point, this invention aims at offering the exposure approach which dishing does not generate on the mark for the alignment, even when the planarizing process for example, in a wiring process etc. is performed on the mark for alignment (wafer mark). Furthermore, this invention aims at offering the mask which can be used by such exposure approach.

[0010]

[Means for Solving the Problem] The 1st process at which the exposure approach by this invention forms the mark for the alignment which consists of a concavo-convex pattern (76X) on a substrate (W) (steps 101-105), The 2nd process which forms a coat (79) on the mark for the alignment of the substrate (76X), and other fields (step 106), The 3rd process (107) which carries out flattening of the coat (79), and the 4th process which applies sensitive material on the coat (79) in which flattening was carried out by this 3rd process, and exposes a mask pattern (steps 108-110), In the exposure approach of ****(ing), the mark for the alignment (76X) formed at the 1st process (steps 101-105) The concavo-convex pattern (74A-74E) (it is also henceforth called "a subpattern (74A-74E)") of a pitch smaller than the predetermined width of face is formed among the heights more than predetermined width of face (75A-75D) (it is also henceforth called "the heights (75A-75D) of the Maine pattern").

[0011] Moreover, in the case of 2 micrometers or more, especially effectiveness has large spacing of the heights (75A-75D) more than the predetermined width of face of the mark for [the] alignment (76X) to this invention. Furthermore, the mask by this invention is set on the mask (R) with which the original edition pattern of the mark for alignment (76X) was formed with the pattern for an imprint, and the original edition pattern of the mark for [the] alignment (76X) forms the light-and-darkness pattern (67A, 67B) of a pitch smaller than said predetermined width of face between two or more bright sections more than predetermined width of face, or dark space (66A, 66B).

[0012]

[Function] According to the exposure approach of this invention, by forming a subpattern (74A-74E) in the field used as a crevice conventionally, spacing of opening for a crevice on Substrate W is written very small, and generating of dishing on the mark for alignment accompanying flattening (76X) is suppressed. Therefore, mark distortion does not take place, either but alignment is performed by high degree of accuracy. Moreover, in the exposure approach of this invention, spacing of the heights (75A-75D) of the Maine pattern of the mark for alignment (76X) can be carried out more than the resolution of an alignment sensor, and spacing of the heights (78) of a subpattern (74A-74E) and crevices (77) can be made into the magnitude below the resolution of an alignment sensor. Therefore, the conventional alignment sensor can perform alignment as usual as a light-and-darkness pattern which makes the Maine pattern and a subpattern (74A-74E) a bright section and dark space, respectively.
[0013] Moreover, since it becomes easy to generate dishing between heights when spacing of the heights (75A-75D) more than said predetermined width of face of the mark for alignment (76X) is set to 2 micrometers or more, generating of dishing is controlled by preparing a subpattern (74A-74E). Moreover, it can use out of resolution also by the alignment sensor which is not good.
[0014] Furthermore, according to the mask (R) of this invention, the subpattern (74A-74E) made in the irregularity which, as for the alignment mark (76X) which carried out the exposure imprint on the substrate (W) using the mask (R), has a pitch below the predetermined width of face between the heights more than the predetermined width of face of the Maine pattern (75A-75D) was formed. For this reason, alignment is performed by high degree of accuracy, without stopping dishing on the mark for alignment (76X) as mentioned above, therefore also causing mark distortion.
[0015]
[Example] Hereafter, it explains with reference to the drawing per example of this invention. Drawing 3 shows the rough configuration of a suitable projection aligner to apply the exposure approach of this example, and in this drawing 3 , once it is reflected in the ellipse mirror 2 and the illumination light IL generated from the extra-high pressure mercury lamp 1 condenses with that 2nd focus, incidence of it is carried out to the illumination-light study system 3 containing a collimator lens, an interference filter, an optical integrator (fly eye lens), an aperture diaphragm (sigma drawing), etc. Although not illustrated, the fly eye lens is arranged at field inboard vertical to an optical axis AX so that the reticle side focal plane may be mostly in agreement with the Fourier transform side (pupil conjugation side) of a reticle pattern.
[0016] Moreover, near the 2nd focus of the ellipse mirror 2, the shutter (for example,

rotary shutter of a four-sheet wing) 37 which performs closeout and disconnection of the illumination light IL of an optical path by the motor 38 is arranged. In addition, as illumination light for exposure, laser beams, such as excimer laser (KrF excimer laser, ArF excimer laser, etc.), or metal vapor laser, the higher harmonic of an YAG laser, etc. may be used other than the bright line of extra-high-pressure-mercury-lamp 1 grade.

[0017] In drawing 3 , after the most is reflected by the beam splitter 4, the illumination light (i line etc.) IL of a wavelength region which exposes the photoresist layer which injected the illumination-light study system 3 passes the 1st relay lens 5, the adjustable field diaphragm (reticle blind) 6, and the 2nd relay lens 7, and results in a mirror 8. And the illumination light IL mostly reflected in the vertical lower part by the mirror 8 illuminates pattern space PA of Reticle R with an almost uniform illuminance through the Maine condenser lens 9. The arrangement side of a reticle blind 6 has the pattern formation side and conjugation relation (image formation relation) of Reticle R, and the lighting visual field of Reticle R can be set as arbitration by making the movable blade of two or more sheets which constitutes a reticle blind 6 by the drive system 36 open and close, and changing the magnitude of opening, and a configuration.

[0018] Here, in drawing 3 , the Z-axis is taken to the optical axis AX of an illumination-light study system and parallel which intersect Reticle R, and a Y-axis is taken at right angles to the space of the X-axis and drawing 3 to parallel in a flat surface vertical to the Z-axis at the space of drawing 3 . Drawing 5 (c) shows the reticle R of this example, and the reticle marks 64X and 64Y as an alignment mark are formed in the reticle R of this drawing 5 (c), respectively into the protection-from-light band 62 of two sides with which the pattern space 61 surrounded by the protection-from-light band 62 intersects perpendicularly and which approached the center section mostly. By projecting the image of these reticle mark on the photoresist layer of Wafer W, and developing it, the image of these reticle mark is formed as a wafer mark of a concavo-convex pattern on the wafer W. Moreover, these reticle marks 64X and 64Y may be shared as an alignment mark at the time of performing each shot field of Wafer W, and alignment with Reticle R. These two reticle marks 64X and 64Y are the same configurations (however, directions differ), and are formed of light-shielding films, such as chromium, in transparence aperture 63X prepared into the protection-from-light band 62 of Reticle R, respectively, and 63Y. Furthermore, the alignment marks 65A and 65B which consist of a protection-from-light nature mark of two cross-joint molds are countered and formed near [the] the periphery at Reticle R. These two alignment marks 65A and 65B are used for the alignment (alignment to an optical axis AX) of Reticle R.

[0019] The reticle mark of the reticle R is explained in more detail with reference to drawing 5 (c) and (d). reticle mark 64X for a reticle mark to perform location detection of the direction of X as shown in drawing 5 (c), and reticle mark 64Y for performing location detection of the direction of Y -- since -- changing, the reticle marks 64X and 64Y consist of five submarks arranged in the transparency section, respectively. Reticle mark 64Y for the directions of Y rotates 90 degrees of reticle mark 64X for the directions of X.

[0020] Drawing 5 (d) shows a part of structure of reticle mark 64X for the directions of X, and sets it to this drawing 5 (d). Reticle mark 64X As opposed to the direction of X between the transparency sections 66A and 66B more than predetermined width of face, and ... The almost same submarks 67A and 67B of width of face as the transparency section and ... are arranged, it is constituted and each submarks 67A and 67B and ... arrange the light-shielding film 68 of the shape of 5 sets of slits, and the slit-like transparency section 69 in a predetermined pitch in the direction of X, respectively.

[0021] these submarks 67A and 67B and ... comrades have spacing more than predetermined width of face, and are formed. Although this spacing is determined in consideration of the resolution of an alignment sensor, when an exposure imprint is carried out on Wafer W, as for spacing of the subpatterns of the submarks 67A and 67B and the wafer mark formed on Wafer W of ..., in this example, being set to 2 micrometers or more is desirable. In addition, the configuration of the submarks 67A and 67B and ... is not limited to the form of drawing 5 (d). Moreover, the reticle marks 64X and 64Y may use the mark which reversed a bright section and dark space.

[0022] now, the submarks 67A and 67B of drawing 5 (d) and ... when the submark is imprinted on Wafer W, the inner light-shielding film 68 and pitch spacing of the transparency section 69 are set up so that the image of the submark may become the magnitude below the resolution of an alignment sensor. In addition, you may be an irregular pattern although the submarks 67A and 67B in reticle mark 64X in this example and ... are regular patterns. However, when it is imprinted on Wafer W, as for spacing of the bright sections of the irregular pattern, or spacing of dark space, it is desirable to be set up so that the internal structure of the subpattern (partial pattern) of the wafer mark formed of the submark may become, whenever [below the resolution of the alignment sensor used for the detection] detailed. In addition, the reticle marks 64X and 64Y can be formed with a well-known optical pattern generator and a well-known electron beam exposure system.

[0023] Here, it returns and explains to drawing 3 again. Reticle R is laid on two-dimensional migration and the minute pivotable reticle stage RS in the level surface

vertical to the optical axis AX by the motor 12 that it can move slightly in the direction (Z direction) of the optical axis AX (it is in agreement with the optical axis of an illumination-light study system) of a projection optical system 13. 11m of migration mirrors which reflect the laser beam from the laser beam wave interference type length measuring machine (laser interferometer) 11 in the edge of a reticle stage RS is fixed, and the two-dimensional location of a reticle stage RS is always detected by the laser interferometer 11 with the resolution of about 0.01 micrometers. Above Reticle R, the reticle alignment systems (RA system) 10A and 10B are arranged, and these RA systems 10A and 10B detect the alignment marks 65A and 65B of two cross-joint molds formed near the periphery of Reticle R. By making a reticle stage RS move slightly based on the measurement signal from the RA systems 10A and 10B, Reticle R is positioned so that the central point of a pattern space 61 may be in agreement with the optical axis AX of a projection optical system 13.

[0024] now, the illumination light IL which passed the pattern space 61 of Reticle R -- a both-sides tele cent -- incidence is carried out to the rucksack projection optical system 13, a photoresist layer is formed in a front face, and the projection image of the circuit pattern of the reticle R reduced by the projection optical system 13 to one fifth is piled up and projected on one shot field on the wafer W held so that the front face might be mostly in agreement with the best image formation side of a projection optical system 13 (image formation).

[0025] Vacuum adsorption is carried out at a minute pivotable wafer holder (un-illustrating), and Wafer W is held on the wafer stage WS through this wafer holder. the wafer stage WS -- a motor 16 -- a step-and-repeat method -- two-dimensional -- after being constituted movable and completing imprint exposure of the reticle R to one shot field on Wafer W, stepping of the wafer stage WS is carried out to the shot location of a degree. 15m of migration mirrors which reflect the laser beam from a laser interferometer 15 in the edge of the wafer stage WS is fixed, and the two-dimensional coordinate of the wafer stage WS is always detected by the laser interferometer 15 with the resolution of about 0.01 micrometers. A laser interferometer 15 measures the coordinate of the direction of X of the wafer stage WS, and the direction of Y, and the stage system of coordinates (rest frame) (X, Y) of the wafer stage WS are defined by the coordinate of the direction of these X, and the direction of Y. That is, the coordinate value of the wafer stage WS measured by the laser interferometer 15 is a coordinate value on stage system of coordinates (X, Y).

[0026] Moreover, on the wafer stage WS, it is prepared so that the criteria member (glass substrate) 14 equipped with the reference mark used in the time of measurement

of the amount of base lines (the reference point of an alignment sensor and spacing based on exposure) etc. may become the almost same height as the exposure side of Wafer W. Moreover, into drawing 3 , the image formation property amendment section 19 which can adjust the image formation property of a projection optical system 13 is also formed. The image formation property amendment section 19 in this example is driving independently each of some lens elements which constitute a projection optical system 13, especially two or more lens elements near Reticle R using piezoelectric devices, such as a piezo-electric element, (it being migration or dip of an parallel direction to an optical axis AX), and amends distortion, the image formation property, for example, the projection scale factor, of a projection optical system 13.

[0027] Next, the alignment sensor (henceforth "Field Image Alignment a system (FIA system)") of an image-processing method is formed in the side of a projection optical system 13 by the off-axis method. In this example, this FIA system performs location detection of a wafer mark. In this FIA system, the light generated with the halogen lamp 20 is led to an interference filter 23 through a condenser lens 21 and an optical fiber 22, and the light of the sensitization wavelength region of a photoresist layer and an infrared wavelength region is cut here. the light which penetrated the interference filter 23 -- a lens system 24, a beam splitter 25, a mirror 26, and field-diaphragm BR -- minding -- a both-sides tele cent -- incidence is carried out to the rucksack objective lens 27. It is reflected by the prism (or mirror) 28 fixed on the outskirts of lens-barrel lower of a projection optical system 13 so that the lighting visual field of a projection optical system 13 may not be shaded, and the light injected from the objective lens 27 irradiates Wafer W almost vertically.

[0028] The light from an objective lens 27 is irradiated by subregion including the wafer mark on Wafer W, and the light reflected from the field concerned is led to the index plate 30 through prism 28, an objective lens 27, field-diaphragm BR, a mirror 26, a beam splitter 25, and a lens system 29. Here, the index plate 30 is arranged in Wafer W and a field [****] about an objective lens 27 and a lens system 29, and image formation of the image of the wafer mark on Wafer W is carried out into the transparence aperture of the index plate 30. Furthermore, that to which only predetermined spacing has detached and arranged the two straight-lines-like mark prolonged in the direction of Y in the direction of X as an index mark is formed in the transparence aperture at the index plate 30. The light which passed the index plate 30 is led to image sensors (CCD camera etc.) 34 through the 1st relay lens system 31, a mirror 32, and the 2nd relay lens system 33, and image formation of the image of a wafer mark and the image of an index mark is carried out on the light-receiving side of

an image sensor 34. The image pick-up signal SV from an image sensor 34 is supplied to the main control system 18, and the location (coordinate value) of the direction of X of a wafer mark is computed here. In addition, although not shown in drawing 3 , 1 set of FIA systems (FIA system for Y-axes) which will accept it in order to detect the location of the wafer mark of the direction of Y are also prepared in everything but the FIA system (FIA system for the X-axes) of the above-mentioned configuration.

[0029] Next, the alignment sensor 17 of a TTL (through THE lens) method is also arranged in the up side of a projection optical system 13, and the light for the location detection from the alignment sensor 17 is led to the projection optical system 13 through mirrors M1 and M2. The light for that location detection is irradiated on the wafer mark on Wafer W through a projection optical system 13, and the reflected light from this wafer mark is returned to the alignment sensor 17 through a projection optical system 13, a mirror M2, and a mirror M1. The alignment sensor 17 asks for the location of the wafer mark on Wafer W from the signal acquired by carrying out photo electric translation of the returned reflected light.

[0030] Drawing 4 shows the detailed configuration of the alignment sensor 17 of the TTL method in drawing 3 , and in this drawing 4 , the alignment sensor 17 of this example carries out the maximum share of that optical member, and combines the alignment system (henceforth a "LIA system") of 2 flux-of-light interference method, and the alignment system (henceforth a "LSA system") of a laser step alignment method. The more concrete configuration is indicated by JP,2-272305,A although explained briefly here.

[0031] In drawing 4 , incidence of the laser beam which the laser beam injected from the light sources (helium-Ne laser light source etc.) 40 was divided by the beam splitter 41, and was reflected here is carried out to the 1st beam shaping optical system (LIA optical system) 45 through a shutter 42. On the other hand, incidence of the laser beam which penetrated the beam splitter 41 is carried out to the 2nd beam shaping optical system (LSA optical system) 46 through a shutter 43 and a mirror 44. Therefore, it can be used by driving shutters 42 and 43 suitably, being able to switch a LIA system and a LSA system.

[0032] Now, the LIA optical system 45 injects mostly two laser beams which gave predetermined frequency difference deltaf to the symmetry on both sides of the optical axis including 2 sets of acoustooptic modulators etc. Furthermore, two laser beams injected from the LIA optical system 45 reach a beam splitter 49 through a mirror 47 and a beam splitter 48, through a lens system (inverse Fourier transform lens) 53 and a mirror 54, with a predetermined crossed axes angle, incidence of the two laser beams

which penetrated this is carried out to the diffraction grating 55 for reference currently fixed on equipment, and they carry out image formation (crossover) to it from a mutually different 2-way. A photodetector 56 receives the interference light of the diffracted lights which penetrate the diffraction grating 55 for reference and are mostly generated in the same direction, and outputs the photoelectrical signal SR of the shape of a sine wave according to diffracted-light reinforcement to the LIA arithmetic unit 58 in the main control system 18 (refer to drawing 3).

[0033] On the other hand, once two laser beams reflected by the beam splitter 49 cross by opening of a field diaphragm 51 with an objective lens 50, incidence of them is carried out to a projection optical system 13 through a mirror M2 (the mirror M1 in drawing 3 is a graphic display abbreviation). Furthermore, once two laser beams which carried out incidence to the projection optical system 13 serve as symmetry mostly about an optical axis AX by the pupil surface of a projection optical system 13 and condense in the shape of a spot, they serve as the parallel flux of light which inclined at the symmetrical include angle mutually on both sides of the optical axis AX about the pitch direction (the direction of Y) of the wafer mark on Wafer W, and carry out incidence with a predetermined crossed axes angle from a different 2-way on a wafer mark. On a wafer mark, the 1-dimensional interference fringe which moves at the rate corresponding to delta-frequency deltaf is formed, from the mark concerned, the primary [**] diffracted light (interference light) generated in the direction of an optical axis is received with a photodetector 52 through a projection optical system 13 and objective lens 50 grade, and a photodetector 52 outputs the photoelectrical signal SDw of the shape of a sine wave according to the period of light-and-darkness change of an interference fringe to the LIA arithmetic unit 58 the same direction and here. The LIA arithmetic unit 58 asks for the coordinate location of the wafer stage WS in case the amount of location gaps concerned serves as zero using the position signal PDs from a laser interferometer 15 while computing the amount of location gaps of the wafer mark from the phase contrast on two waves of the photoelectrical signals SR and SDw.

[0034] Moreover, the LSA optical system 46 carries out incidence of the laser beam injected from the LSA optical system 46 to an objective lens 50 through beam splitters 48 and 49 including a beam expander, a cylindrical lens, etc. Furthermore, once converging in the shape of a slit by opening of a field diaphragm 51, incidence of the laser beam injected from an objective lens 50 is carried out to a projection optical system 13 through a mirror M2. The laser beam which carried out incidence to the projection optical system 13 is projected on Wafer W as a long and slender band-like spot light which faces to elongation and an optical axis AX in the direction of X in the

image field of a projection optical system 13, after [the pupil surface] passing along a center mostly.

[0035] The light which generates spot light and the wafer mark on Wafer W (diffraction-grating mark) from the wafer mark concerned when displaced relatively in the direction of Y is received with a photodetector 52 through a projection optical system 13 and objective lens 50 grade. A photodetector 52 outputs the photoelectrical signal SDi according to the optical reinforcement obtained by carrying out photo electric translation only of primary [**] - the 3rd diffracted light among the light from a wafer mark, and carrying out photo electric translation in this way to the LSA arithmetic unit 57 in the main control system 18. The position signal PDs from a laser interferometer 15 is also supplied to the LSA arithmetic unit 57, and the LSA arithmetic unit 57 samples the photoelectrical signal SDi synchronizing with the up-and-down pulse generated for every unit movement magnitude of the wafer stage WS. Furthermore, after the LSA arithmetic unit's 57 changing each sampling value into digital value and making memory memorize it in order of an address, it computes the location of the direction of Y of a wafer mark by predetermined data processing. Moreover, the alignment sensor for the X-axes which detects the location of the wafer mark of the LIA method for the X-axes and the location of the wafer mark of a LSA method is also formed separately.

[0036] Next, with reference to the flow chart of drawing 1 , it explains per example of the exposure actuation in this example. First, in step 101 of drawing 1 , a photoresist is applied on Wafer W by non-illustrated coater, baking is performed if needed, the wafer W is loaded on the wafer stage WS of the projection aligner of drawing 3 in step 102, and the reticle R of drawing 5 (c) is loaded on the reticle stage RS of drawing 3 . Next, in step 103, through the projection exposure system 13, it reduces to one fifth and the circuit pattern and the reticle marks 64X and 64Y in the pattern space 61 on the reticle R of drawing 5 (c) are projected on the photoresist layer applied on Wafer W. Thereby, as shown in drawing 5 (a), a circuit pattern image is projected into the shot field SA on Wafer W, and image 70of image 70X [of reticle mark 64X] and reticle mark 64Y Y is projected near the shot field SA. For example, image 70X of reticle mark 64X arranges the images 71A, 71B, ..., 71E of a submark in the direction of X in a predetermined pitch, as shown in drawing 5 (b). The images 70X and 70Y of these reticle mark serve as a wafer mark which consists of a concavo-convex pattern after processing of development etc.

[0037] After the wafer W with which the circuit pattern on Reticle R and the image of the reticle marks 64X and 64Y were imprinted is developed in step 104, in step 105,

etching processing is again washed after a carrier beam if needed by using a resist pattern as a mask after baking processing. There is a DIP method which fixed-time-dips a predetermined penetrant remover and a predetermined developer in the spray method which makes the shape of the shape of fuel spray and a shower, and is sprayed or a developer, or a penetrant remover, and develops them in the processing equipment used at step 104, and Wafer W is developed and washed by which approach in this. Moreover, although etching is performed by a wet method or the dry method, it is processed by the dry method in many cases, and a plasma etching system is used for this dry etching by the end of today.

[0038] At step 105, termination of etching is detected with the laser-beam interference method using a spectral-analysis method or an optical echo, an ellipsometric method, or grating optical diffraction, and after carrying out a termination check, Wafer W is washed as occasion demands. Thus, a resist layer and an unnecessary oxide-film part, or a metal membrane part is removed, and as shown in drawing 2 (b), a required circuit and wafer mark 76X are formed in the shape of irregularity in the coat 73 on the coat 72 on Wafer W (low-ranking circuit patterned layer). This wafer mark 76X is formed from the image which imprinted reticle mark 64X for the X-axes on Wafer W according to the cutback scale factor of a projection optical system PL.

[0039] Drawing 2 shows wafer mark 76X formed on Wafer W of the imprint of the wafer mark formed by this example, i.e., reticle mark 64X. In addition, the flattening layer by the insulator layer (or metal membrane) mentioned later is also displayed on this drawing 2 , and it is used also in case a flat chemically-modified degree is explained. Drawing 2 (a) is the sectional view which looked at wafer mark 76X for the X-axes from Y, and drawing 2 (b) is the top view of the wafer mark 76X.

[0040] Wafer mark 76X is what was formed with the circuit into the coat 73 formed on the coat 72 on Wafer W as above-mentioned as it is shown in drawing 2 (a) and (b). Two or more heights 75A-75D are formed in the meantime with spacing more than predetermined width of face considering a coat 73 as heights 73a and 73b of ends, respectively, and the subpatterns 74A-74E which consist of a detailed concavo-convex pattern which consists of heights 78 and a crevice 77 are further formed among these heights. Here, the width of face P1 of each subpattern and the width of face P2 of each heights have predetermined die length (at this example, P1 and P2 are about 6 micrometers, respectively), and are formed, respectively. Moreover, although the width of face P3 of the heights 78 of a subpattern or a crevice 77 is formed by predetermined die length, it is setting width of face P3 to about 0.67 micrometers in this example. However, if this width of face P3 is width of face by which detection processing is

carried out as dark space of the alignment sensor used, a limit will not have it in that width of face. Moreover, although referred to as about 6 micrometers in this example, if the spacing (namely, width of face of a subpattern) P1 of the heights of mark 76X is the width of face more than the resolution of the alignment sensor used also about this width of face, especially a limit will not have it. However, if it may be able to do, as for spacing P1, it is desirable to make it 2 micrometers or more. By the mark sensor of a FIA method, since it is unresolvable, the subpatterns 74A-74E of the alignment sensor formed as mentioned above can be processed as a light-and-darkness pattern which makes a bright section the heights 75A-75D of wafer mark 76X, and makes dark space the subpatterns 74A-74E. In addition, wafer mark 76Y as well as wafer mark 76X is formed.

[0041] As mentioned above, next, in step 106,107, in order to form the upper circuit further, flattening of the front face on the wafer W with which a predetermined circuit and the predetermined wafer marks 76X and 76Y were formed is carried out. Although this flattening is performed by the above-mentioned approach, in step 106, the insulator layers (or it is called the "flattening film" a metal membrane and henceforth) 79, such as silicon oxide (SiO_2), are first covered with this example on Wafer W. In this phase, as shown in drawing 2 (a), very small irregularity is looked at by surface 79a of the flattening film 79. Next, in step 107, processing which grinds surface 79a of the flattening film 79 in chemical machinery is performed. This chemical machinery-polish is performed by the approach of grinding the front face of the flattening film 79 mechanically, adding a predetermined chemical or water as occasion demands.

[0042] The condition of the front face 80 of the wafer W by which flattening was carried out to drawing 2 (a) by the above approach, especially the flattening film 79 on wafer mark 76X is shown. The front face 80 of the flattening film 79 forms the gently-sloping field, without denting on wafer mark 76X. By having filled between the heights 75A-75D of wafer mark 76X with the detailed subpatterns 74A-74E, the crevice 2 micrometers or more of this is lost, and it is because the surface smoothness of the flattening film 79 on wafer mark 76X is maintained as the above-mentioned explanation.

[0043] On the wafer W with which flattening of the flattening film 79 front face was carried out, a photoresist is again applied in step 108 by the above process. Here, Wafer W is rotated, for example and photoresist coaters (coater), such as a spin coat method which forms the thin film of a photoresist on Wafer W according to a centrifugal force, are used. The wafer W with which the photoresist was applied is again set in step 109 on the wafer stage of the above-mentioned projection aligner, the suitable projection aligner for the exposure approach of other this examples, or common pattern formation

equipment.

[0044] If the flattening film 79 is a transparent insulator layer like silicon oxide and the wafer marks 76X and 76Y are metals in a place, even if the flattening film 79 is formed all over including the wafer marks 76X and 76Y on Wafer W, the wafer marks 76X and 76Y are detectable by the alignment sensor of the FIA system which is an image-processing method. However, when the flattening film 79 is a metal, for example, the wafer marks 76X and 76Y are not detected. Therefore, what is necessary is to prepare the part by which flattening is not carried out on Wafer W, and just to make it form another wafer mark there in that case. Thus, if detection is possible, alignment of the wafer W set to the above-mentioned wafer stage WS will be carried out as mentioned above using the alignment sensor of the above-mentioned FIA system.

[0045] In addition, detection and alignment of the wafer mark can be performed by the alignment sensor of a LSA method or a LIA method, respectively about the wafer mark of a LSA system or a LIA system as well as a FIA system. In step 110, a new wafer mark is again formed here if needed [a new circuit pattern and if needed / new] using another reticle. At this time, there is no dished depression by the above-mentioned dishing phenomenon in the new formation location of a wafer mark, and the stable wafer mark without mark distortion is formed in it in the front face 80 of the flattening film 79 on Wafer W.

[0046] Drawing 6 shows another example of the wafer mark for the X-axes of the FIA system used for the exposure approach of this invention, and drawing 6 (a) is the wafer mark which used the detailed subpattern as line - and - tooth-space pattern which were arranged in the non-measuring direction, and is formed of the line marks 81A, 81B, and 81C which consist of two or more sets of heights 83, and a crevice 82 below predetermined width of face. The line marks 81A, 81B, and 81C form a crevice 82 and heights 83 in the direction of Y in a predetermined pitch here, respectively. Drawing 6 (b) is the wafer mark which made the detailed subpattern the shape of a two-dimensional grid, and is formed of the line marks 84A, 84B, and 84C with the concavo-convex pattern of the shape of a respectively detailed grid. here -- the line marks 84A, 84B, and 84C -- drawing 6 (a) -- it is similarly formed with spacing more than predetermined width of face. Moreover, drawing 6 (c) shows the wafer mark which made the detailed subpattern the shape of a random dot, and is formed of the line marks 85A, 85B, and 85C with the heights of the shape of a respectively random dot. Here, the line marks 85A, 85B, and 85C have spacing more than predetermined width of face like drawing 5 and 6, and are formed. In addition, the alignment mark with such a detailed subpattern can use not only a FIA system but other alignment sensor systems, such as a

LSA system and a LIA system.

[0047] Drawing 7 shows the wafer mark for LSA, and is formed from pattern 86B for the X-axes which consists of two or more combination of the detailed subpattern 87 which consists of a concavo-convex pattern of the shape of a slit parallel to the X-axis, pattern 86A for Y-axes which consists of two or more combination with heights 88, and the subpattern 89 which consists of a concavo-convex pattern parallel to a detailed Y-axis. The wafer mark used for the exposure approach of this invention is applicable also like the wafer mark of other configurations.

[0048] Moreover, this invention is applicable not only like the aligner of a stepper mold but the aligner of step - exposed by scanning reticle and a wafer relatively, and - scanning method. Thus, this invention is not limited to the above-mentioned example, but can take configurations various in the range which does not deviate from the summary of this invention.

[0049]

[Effect of the Invention] According to the exposure approach of this invention, even if it performs flattening processing, dishing does not occur on the mark for alignment. Therefore, distortion of the detection light of the mark for the alignment at the time of alignment can be suppressed, and alignment precision improves. Moreover, to the equipment side which carries out an exposure imprint, modification on a device is unnecessary, therefore simple to it.

[0050] Moreover, when spacing of the heights of the mark for alignment is set to 2 micrometers or more, the alignment sensor of the conventional usual resolution can detect the mark for the alignment. Moreover, although spacing becomes easy to generate dishing especially in 2 micrometers or more, generating of dishing can be controlled by this invention. Furthermore, according to the mask of this invention, the mark for alignment which carried out the exposure imprint on the substrate using the mask can attain the alignment of high degree of accuracy in a flattening processing process, without stopping dishing on the mark for alignment, therefore also producing mark distortion.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the flow chart which shows exposure actuation of one example of this invention.

[Drawing 2] The sectional view of a wafer mark where (a) is used in the example, and (b) are the top views of the wafer mark.

[Drawing 3] It is the block diagram showing a suitable projection aligner to enforce the exposure approach of an example.

[Drawing 4] It is the block diagram showing the alignment sensor of the LSA system used for the projection aligner of drawing 3 , and a LIA system.

[Drawing 5] The top view in which the top view showing the circuit pattern with which (a) was exposed on the wafer, and the image of a reticle mark, and (b) show some amplification top views in drawing 5 (a), and (c) shows pattern arrangement of the reticle of an example, and (d) are the amplification top views showing a part of reticle mark in drawing 5 (c).

[Drawing 6] It is drawing showing other examples of the wafer mark of a FIA system, and the amplification top view showing the wafer mark to which (a) considered the detailed subpattern as line [of the non-measuring direction] - and - tooth-space pattern, the amplification top view showing the wafer mark to which (b) considered the detailed subpattern as the shape of a two-dimensional grid, and (c) are the amplification top views showing the wafer mark which made the detailed subpattern the shape of a random dot.

[Drawing 7] It is the amplification top view showing the example of a LSA system wafer mark.

[Drawing 8] It is the explanatory view of generating of the conventional dishing.

[Drawing 9] It is drawing showing the condition that dishing occurs on the conventional wafer mark.

[Description of Notations]

1 Light Source
3 Illumination-Light Study System
9 Maine Condenser Lens
R Reticle
13 Projection Optical System
W Wafer
WS Wafer stage
15 Laser Interferometer
18 Main Control System
67A, 67B Submark of a reticle mark
64X, 64Y Reticle mark
76X The wafer mark of the direction of X
73a, 75A-75D, 73b Heights of a wafer mark
74A-74E Subpattern of a wafer mark
79 Flattening Film